Recent Population Trends of Double-Crested Cormorants Wintering in the Delta Region of Mississippi: Responses to Roost Dispersal and Removal Under a Recent Depredation Order

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Abstract.—The purpose of this study was to examine recent trends in cormorant wintering populations and their economic impact in the delta region of Mississippi and to examine the response of these populations to management efforts directed at reducing their predation on channel catfish (*Ictalurus punctatus*). We monitored Double-crested Cormorant (*Phalacrocorax auritus*) populations in the delta region of Mississippi through the use of mid-winter ground counts and aerial surveys during the winters of 1995-96 through 1998-99 and surveyed the reported take of cormorants by catfish farmers in the region under the recently-enacted Cormorant Depredation Order. This order issued by the U.S. Fish and Wildlife Service in March, 1998 allowed catfish farmers in the region to kill unlimited numbers of cormorants seen causing depredations at their farms. Despite roost dispersal programs and continued harassment of birds at farms, cormorant populations have significantly increased and based on ground counts have doubled from approximately 32,000 birds to more than 64,000 birds between 1995 and 1999. Mid-winter ground counts and aerial counts were highly correlated and the best linear prediction of ground counts (Y) from aerial counts (b) took the form Y = 1.55 b, (Y-intercept = 0). Roost dispersal programs continue to have the desired effect of shifting birds away from areas of highest catfish concentration, but these effects are temporary at best. However, without such programs, the impact of cormorant depredations on the catfish industry in 1997-98 and 1999-98 probably would have more than doubled compared to previous years. Catfish farmers in the delta region of Mississippi reported taking more cormorants under the Cormorant Depredation Order than previously reported under past depredation permits issued to individual farmers. The reported take of at least 9,557 birds by Mississippi catfish farmers had no apparent impacts on wintering populations during 1998-99. Further monitoring of cormorant wintering populations over more of their wintering range is recommended. *Received 27 September 1999, accepted 5 December 1999.*

Key words.—Channel catfish, depredation control, Double-crested Cormorant, *Ictalurus punctatus*, Mississippi, *Phalacrocorax auritus*, wintering populations.

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Wintering populations of Double-crested Cormorants (*Phalacrocorax auritus*) in the lower Mississippi Valley increased dramatically during the 1970's and 1980's (Alexander 1977-1990). These increases parallel the rapid growth of Interior breeding populations (Dolbeer 1991, Tyson *et al.* in press), particularly in the Great Lakes region (Dolbeer 1991). The corresponding growth of the catfish industry in the lower Mississippi Valley has also contributed to increased wintering populations (Glahn and Stickley 1995) and possibly has increased the overwinter survival of these birds (Glahn *et al.* in press). As the growth of the catfish industry slowed in the early 1990's, cormorant populations in the delta region of Mississippi appeared to stabilize at approximately 30,000 birds (Glahn *et al.* 1996). Since the early 1990's, Breeding Bird Survey data for cormorants in the Mississippi flyway indicate a mean annual increase of 22% (Sauer *et al.* 1997) and the number of nesting pairs in the Great Lakes Region has more than doubled from 1991 to 1997 (Tyson *et al.* in press).

In response to cormorant depredations on the catfish industry in the delta region of Mississippi (Glahn and Brugger 1995; Glahn and Stickley 1995; Reinhold and Sloan in press) U.S. Department of Agriculture, Wild-

life Services, in conjunction with catfish farmers, initiated a region-wide cormorant roost dispersal program during the winters of 1993-1994 and 1994-1995 (Mott *et al.* 1998). Despite some success in shifting roosting cormorants away from intensely farmed areas in the region, no changes in overall cormorant populations were consistently observed (Mott *et al.* 1998). Based on the success of cormorant roost dispersal, this program was continued during the winters of 1996-1997 through 1998-1999. In March 1998, the U.S. Fish and Wildlife Service issued a depredation order for the Double-crested Cormorant (USFWS 1998), hereafter referred to as the Cormorant Depredation Order, that allowed catfish farmers in the region to shoot unlimited numbers of cormorants seen causing depredations at their farms. From 1996 to 1999, Wildlife Services personnel continued to monitor cormorant populations in the delta region of Mississippi through a mid-winter ground census of all known roost sites in the region and periodic aerial surveys of roosting populations each winter.

The purpose of this paper is to report on current trends in cormorant populations in this region in response to cormorant roost dispersal efforts and to one full year of cormorant control under the depredation order. To more thoroughly assess cormorant population trends and their relative impact on the catfish industry, we developed a simple linear regression model that relates aerial surveys to ground surveys.

METHODS

Ground counts of wintering cormorants were conducted during the second or third week of February each year from 1996 to 1999 to correspond with similar census times and peak numbers observed in previous years (Glahn *et al.* 1996). Censusing procedures generally followed those of Glahn *et al.* (1996), but because the number of identified roost sites increased, the census involved deploying up to 25 experienced observers. The increasing number of roost sites surveyed also required surveying selected sites along driving routes that connected from three to six roost locations. During the first evening of the census, we traversed this route and briefly stopped at each roost site twice to look for cormorants flying into these sites. When cormorants were seen, we counted birds leaving the roost the following morning; otherwise we assumed the roost was not active. We summarized these data among years, considering the total number of roosts counted, the number of major (>1,000 birds) active sites and the roosting populations along the Mississippi River and in the east-central or "interior" delta region of Mississippi (Mott *et al.* 1998).

Aerial surveys also generally followed procedures of Glahn *et al.* (1996) and were conducted during the winters of 1993-1994, 1994-1995, 1996-1997, 1997-1998 and 1998-1999 and involved four different observers over this period. Survey flights spanned the last three hours before sunset, using a Cessna 182 at an altitude of between 150 and 200 m and a flight speed of approximately 200 km/h. Flights were usually conducted over two consecutive afternoons to cover the entire study area and followed flight plans that visited all known roosting locations, as well as other possible sites. We employed correlation (PROC CORR, SAS Inst. 1996) and regression analyses (PROC REG, SAS Inst. 1996) to relate total aerial survey counts made closest to the February ground census for the years of 1994, 1995, 1997, 1998 and 1999. A one-way ANOVA (PROC GLM, SAS Inst. 1996) was used to compare differences among years in aerial counts taken from mid-January until mid-March.

Using projections of average monthly populations from aerial counts for the winters of 1997-1998 and 1998-1999, we calculated replacement costs of catfish losses due to cormorant depredations from previous bioenergetic models (Glahn and Brugger 1995). Where monthly population averages were lacking in April, we assumed the number to be half the previous total in late March or early April. These calculations also assumed similar monthly changes in diet (Glahn *et al.* 1995) and other parameters previously reported for this region (Glahn and Brugger 1995).

In May 1999, we mailed letters to 152 catfish producers who had previously held depredation permits, asking them to report the number of cormorants taken each month under the Cormorant Depredation Order. Producers were also asked to report the water acreage of their farms.

RESULTS

Since 1995, mid-winter ground counts of cormorants more than doubled from almost 32,000 birds to more than 64,000 birds, as did the number of major (>1,000 bird) active roosts and known alternative sites (Table 1). During years of roost dispersal efforts, most of these birds were distributed at sites along the Mississippi River during ground counts (Table 1), but their distribution varied over time, based on aerial counts (Fig. 1). Aerial counts during the winters of 1996-1997, 1997-1998 and 1998-1999 also showed significant ($P < 0.05$) increases in populations since 1994-1995 during the period from mid-January to mid-March (Fig. 2). Total mid-winter aerial counts from February of these same winters were highly correlated with corresponding mid-winter ground counts (r =

Table 1. Number of known roost sites, major (>1,000 bird) active sites and Double-crested Cormorants counted at roosts by ground observers in the east-central delta (Interior Roosts) and along the Mississippi River (River Roosts) and overall (All Roosts) during February of 1990 through 1999 in the delta region of Mississippi.

	Number of sites		Number of Double-crested Cormorants counted		
Year	Known	Active	Interior roosts	River roosts	All roosts
1999	72	14	18,760	45,409	64,169
1998	64	14	11,472	56,707	68,179
1997	55	12	14,924	40,100	55,024
1996	55	8	16,176	24,574	40,750
1995	54	6	7,932	23,820	31,752
1994[1]	49	5	5,853	10,552	16,405
1993	32	6	23,059	10,781	33,840
1992	22	6	16,452	10,900	27,352
1991	16	6	20,419	10,653	31,072
1990	12	8	18,686	9,898	28,584

[1]First year of cormorant roost harassment programs. The low count this year could have been also due to unusually cold temperatures.

0.978, P = 0.004). The most significant (P = 0.0001) linear prediction of ground counts (Y) from aerial counts (b) took the form of Y = 1.55 b, where the Y intercept was zero. Average monthly predictions of ground counts from aerial counts in 1997-1998 and 1998-1999 were much higher than average monthly ground counts from 1989-1990 and 1990-1991 (Table 2). Based on monthly cormorant populations in 1997-1998 and 1998-1999, bioenergetic modeling projected economic losses due to cormorant predation on catfish at $4.8 million and $4.9 million, respectively. This loss was based on the replacement cost of approximately 47 million and 48 million catfish projected to have been consumed by wintering cormorant populations. Consistent with peak populations occurring in March (Table 2), projected catfish losses were the highest that month in both years, ranging from 15.7 million to 20.5 million fish.

Of the 152 surveys sent out concerning the take of cormorants under the Cormorant Depredation Order, 62 producers from the delta region of Mississippi responded. These producers reported taking 9,557 cormorants and represented 17,955 ha of catfish, or almost 45% of the total catfish acreage in the region. Producers took cormorants throughout the year, (Fig. 3), but most (63%) birds were killed in January, February and March.

DISCUSSION

Recent increases in cormorant wintering populations in the delta region of Mississippi appeared to parallel the continued growth of breeding populations in the Great Lakes region (Tyson *et al.* in press), as well as the modest growth of the Mississippi catfish industry since 1995. Cormorants breeding in the Great Lakes region increased from 38,000 pairs in 1991 (Weseloh *et al.* 1995) to about 93,000 pairs in 1997 (Tyson *et al.* in press). After several years of negligible growth, the Mississippi catfish industry started to expand acreage in 1996 with the addition of 1,600 hectares, a 4% increase (USDA 1996). Pond acreage continued to increase from one to five percent each year thereafter (USDA 1997, 1998, 1999).

Increasing cormorant populations in the delta region of Mississippi are potentially having an increasing impact on the catfish industry. Glahn and Brugger (1995) estimated that a wintering cormorant population, averaging less than half current levels, would consume approximately 20 million catfish fingerlings annually with a replacement value of approximately $2 million. Assuming a similar percent composition of catfish in the diet in 1997-98 and 1998-99 (as found by Glahn *et al.* 1995), wintering cormorants may now be costing Mississippi catfish producers up to $4.9 million annually. However, this projection reflects only replacement costs, not losses at harvest and assumes that all previous parameters of the bioenergetic model except populations were identical to those observed in 1989-1990 and 1990-1991 (Glahn and Brugger 1995). Some of these parameters may in fact have changed. For instance, the success of roost dispersal programs in temporarily shifting cormorants away from catfish production areas (Mott *et al.* 1998) may have lessened their impact by lowering the overall biomass composition of catfish in their diet.

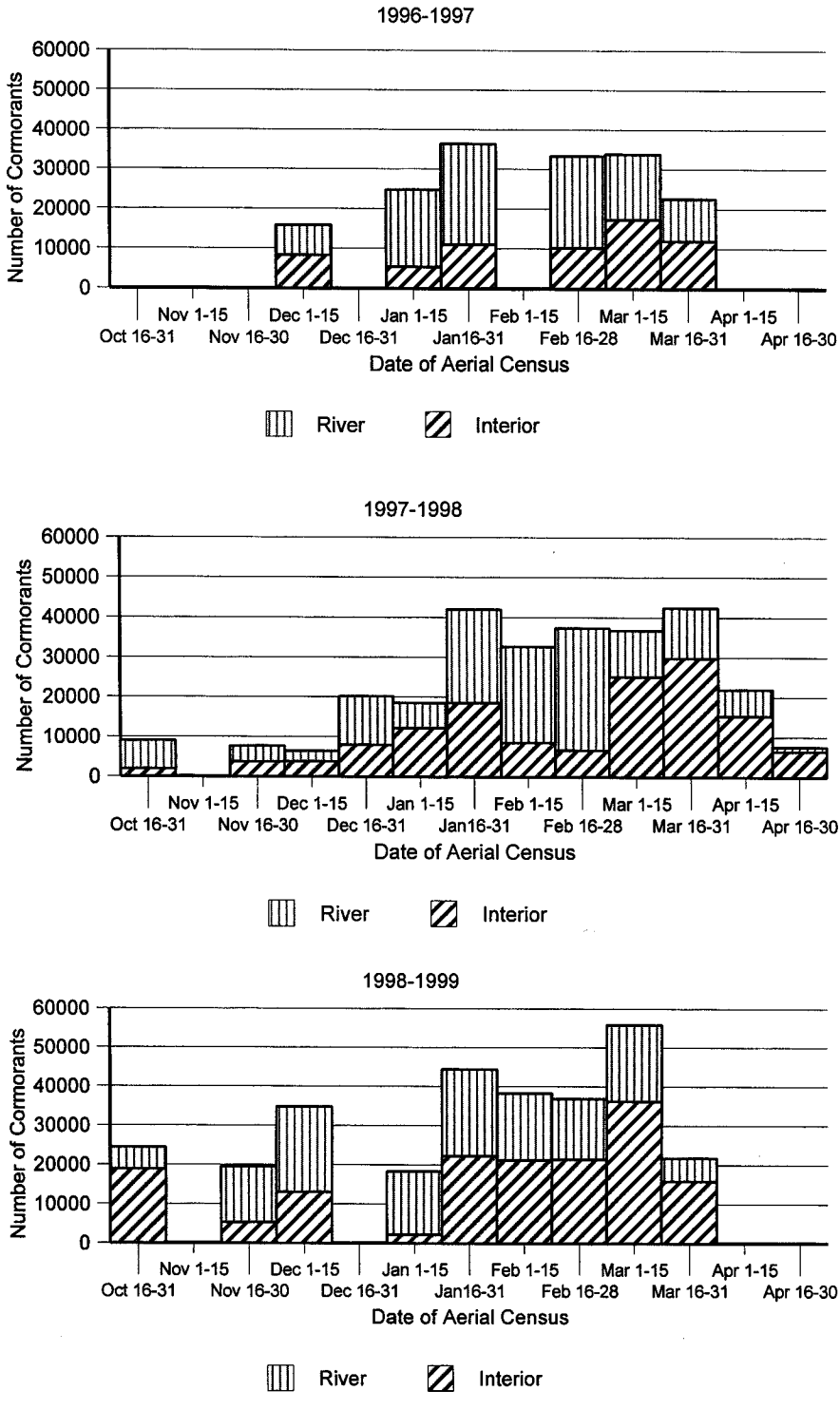

Figure 1. Seasonal changes in the distribution of winter roosting cormorant populations comparing birds roosting along the Mississippi River (River) with those in the Interior delta (Interior) and based on total aerial counts during the winters of 1996-97 through 1998-99.

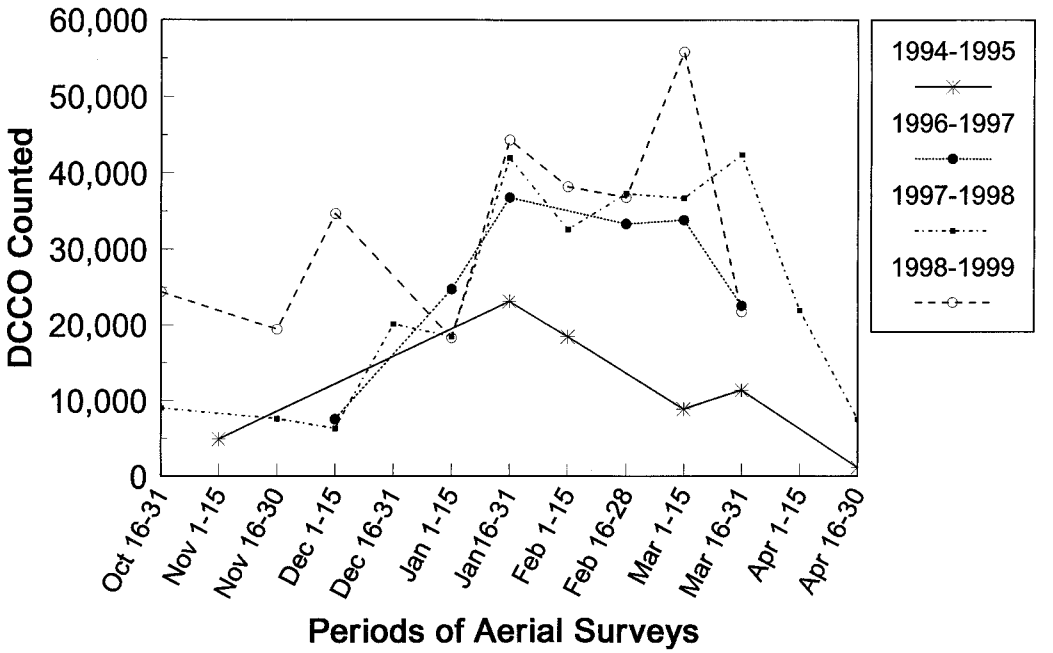

Figure 2. Seasonal changes in total aerial counts of winter roosting cormorants among years 1994-1995, 1996-1997, 1997-1998 and 1998-1999 in the delta region of Mississippi.

The growth of wintering cormorant populations has come despite cormorant roost dispersal programs (Mott *et al.* 1998) and harassment efforts at catfish farms (Mott *et al.* 1998; Reinhold and Sloan in press). Although annual ground counts indicated that roost dispersal programs were effective in shifting cormorants to the Mississippi River, where they were less likely to pose a problem to the catfish industry (Mott *et al.* 1998), aerial survey data suggested that these effects are only temporary. Another probable effect of roost dispersal programs has been the continued increase in the number of known roosting sites in the delta (Mott *et al.* 1998). Since roost dispersal programs began in 1993-1994, the number of known roost sites has also more than doubled to 72 in 1999. Although only a fraction of these sites are used at any one time, this increase has made monitoring populations and conducting successful roost dispersal programs more difficult. For roost dispersal programs to be successful, an adequate number of participants are necessary to simultaneously harass all known roost sites on a sustained basis (Mott *et al.* 1998). If current trends in the number of roost sites continue, there will not be enough catfish producers to successfully conduct such a program in the future.

Although it is too early to tell what long-term effects the newly established Cormorant Depredation Order might have on cormorant populations in the delta region of Mississippi, it has not had any apparent immediate effect. Mississippi catfish producers reported taking a greater number of cormorants under the more liberal Depredation Order than they previously reported under the depredation permit system, but the unreported number killed remains difficult to estimate. Between 1987 and 1995, depredation permit holders from Mississippi reported taking a combined total of 5,301 cormorants (Belant *et al.* in press) compared to more than 9,000 cormorants from 1998-1999 alone. The take of cormorants appears to parallel seasonal trends in cormorant populations. Possibly due to establishment of cormorant breeding colonies in the region (Reinhold *et al.* 1998), cormorants were taken during every month of the year in 1998-1999, with most of the cor-

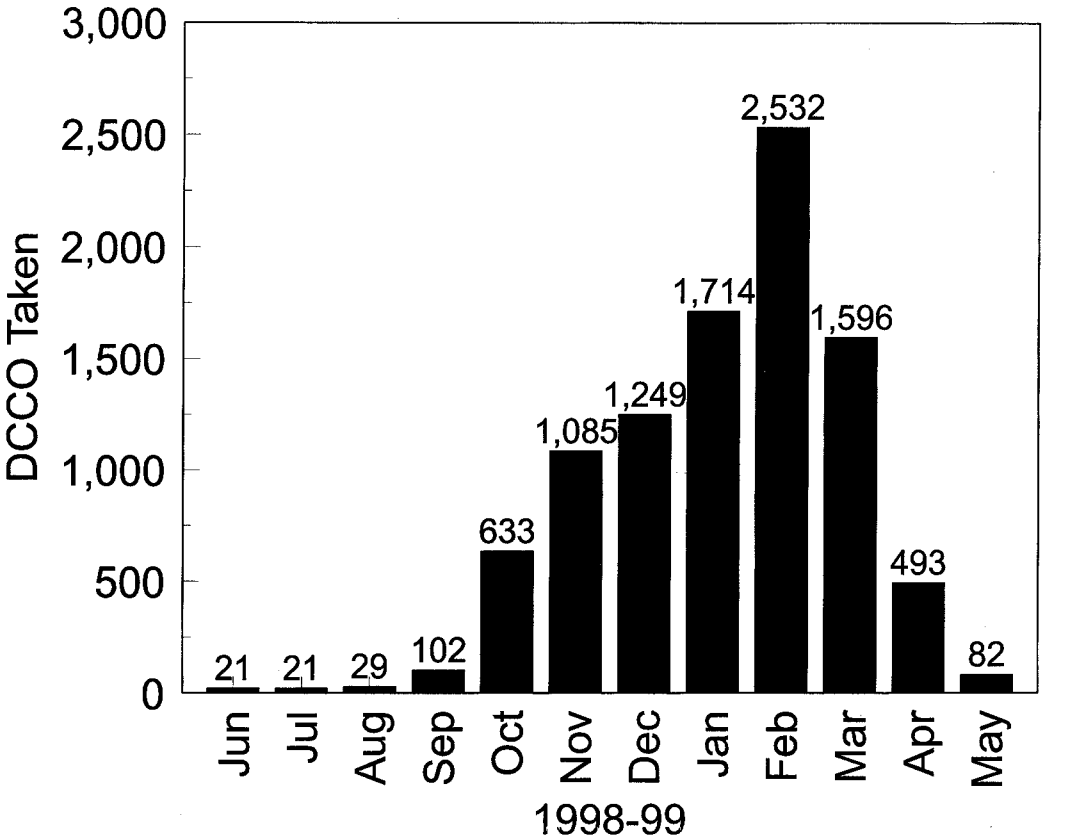

Figure 3. Monthly totals of double-crested cormorants reported taken under the Cormorant Depredation Order by 62 catfish farmers in the delta region of Mississippi in 1998-1999.

morants taken during the period of peak populations from January through March.

Because of increasing numbers of known roost sites in the study area, conducting traditional ground counts in the region has required modifying procedures and deploying up to 25 observers over a two-day period. Glahn *et al.* (1996) found that aerial surveys were useful in identifying new roosting locations and predicting the presence or absence of significant roosting populations, but their use to predict total roosting popu-

Table 2. Average monthly predictions (Y = 1.55 b) of wintering cormorant populations in the delta region of Mississippi from aerial counts in 1997-98 and 1998-99 compared to average monthly population estimates from ground counts in this region during the winters of 1989-90 and 1990-91.

	Winters of ground counts[1]		Winters of aerial counts	
Month	1989-90	1990-91	1997-98	1998-99
November	9,622	9,834	12,865	33,948
December	13,678	17,547	20,494	54,200
January	7,374	22,087	46,835	48,385
February	21,883	23,914	54,188	58,147
March	27,114	20,732	61,285	60,100
April	12,716	6,912	16,980[2]	16,848[2]

[1]Data from Glahn and Brugger (1995).

[2]Estimates based on dividing the predicted values from early April and late March in half.

lations has not been previously reported. Based on a simple regression equation, aerial counts consistently underestimated the total population by about 30%. Although a number of variables likely influence this relationship, the underestimate was probably due to surveying some sites before all birds had entered the roost. Considering the current trends in wintering cormorant populations and the possible future effects of the Cormorant Depredation Order on these populations, further population monitoring is warranted and should be extended to include other areas where wintering cormorants are affecting aquaculture.

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